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AI Enabled Prognostication System in Higher Education using Academic Analytics

A Proposed Ph. D. Synopsis in the Subject Computer Science
Under the Faculty of Science and Technology

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Table of Contents

1. **Introduction** 3
2. **Literature Review** 7
3. **Research Objectives** 11
4. **Research Methodology** 12
5. **Challenges & Ethical Considerations** 15
6. **Possible Outcomes** 16
7. **Possible outcome / Conclusion & Time Schedule** 17
8. **References** 18

1. INTRODUCTION

Abstract

Prognostication in the context of Academic Analytics refers to the use of data analysis techniques to predict future outcomes or trends related to student performance, faculty research productivity, or overall institutional health, essentially allowing institutions to anticipate potential issues and take proactive measures based on data-driven insights. Academic Analytics, empowered by Artificial Intelligence (AI) is reshaping the education landscape by transforming how institutions assess performance, forecast trends, and make data-driven decisions. This proposed research work explores the methodologies, applications, and future potential of AI in Academic Analytics and, emphasizing its role in enhancing institutional effectiveness and better academic performance of students. Key points about prognostication and Academic Analytics include data driven predications, early intervention and future productivity.

Keywords

Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL), Data Mining (DM), PredictiveAnalysis (PA), Higher Education (HE), Performance, Academic Analytics

Introduction to the Scope of the work

The integration of Artificial Intelligence into Academic Analyticsis an emerging field of research that marks a transformative era in education. Institutions worldwide are leveraging these technologies to optimize learning processes, enhance decision-making, and predict trends effectively.

The underlined research work understands artificial intelligence (AI) in terms of evolving technologies like MachineLearning (ML), Deep Learning (DL), Data Mining (DM), and Predictive Analytics (PA). AI in Higher Education helps us to find significant insights from the massive data. In a country like India with huge population, educational institutions like Universities, Colleges, Autonomous Institutions, etc., are unable to provide sustainable education as they lack the knowledge of the current trends, industrial requirements, effectiveness of teaching, learning outcomes and the quality of the students being admitted. AI in terms of ML, DL, DM, PA, can be used to build a complete road map for improving the academic performance of students in various directions. This is primarily done by using existing academic data. As an output, we are able to forecast the ways of improving the academic performance of the students for sustainable growth of the students primarily and their institution secondarily.

With Machine Learning Algorithms, Predictive Analytics can identify early warning signs of academic struggles or disengagement by analyzing student data, behavior patterns, and historical trends, thus enabling educators to proactively intervene by providing students with targeted support that ultimately improves their outcomes.

Predictive Analytics has long held promise for improving educational outcomes. However, traditional techniques often fall short of capturing the complexities of individual learning journeys. This is where Artificial Intelligence (AI) and Machine Learning (ML) come in, offering a powerful toolbox to transform overall sphere of higher education. AI-powered Predictive Analytics utilize a variety of indicators to forecast potential academic difficulties. Here are some of the key indicators used to predict student struggles:

A. Academic Performance Metrics:

1. **Grades:** Low grades or consistent underperformance in coursework can signal academic struggles.
2. **Attendance:** Frequent absences may indicate disengagement or challenges.

B. Demographic and Socioeconomic Factors:

1. **First-Generation Status:** Students who are the first in their family to attend college may face unique challenges due to a lack of familial experience in navigating higher education systems, which can impact their academic performance and engagement.
2. **Financial Constraints:** Financial stress can impact academic performance, as students may need to balance work and studies or face difficulties affording necessary resources.
3. **Ethnicity and Gender:** Certain groups may be more vulnerable to academic struggles due to systemic inequities, discrimination, or cultural barriers that can affect their educational experience and access to support services.

C. Behavioral Patterns:

1. **Course Engagement**: Active participation, interaction with peers, and engagement with course materials are positive signs.
2. **LMS (Learning Management System) Data**: Tracking student interactions within online platforms can reveal patterns.

D. **Early Warning Signs**:

1. **Course Withdrawals**: Dropping courses early in the semester.
2. **Low Quiz or Assignment Scores**: Consistently poor performance on assessments.
3. **Incomplete Assignments**: Missing deadlines or incomplete work.

E. Social and Emotional Factors:

1. **Social Isolation**: Lack of social connections can impact motivation.
2. **Stress and Mental Health**: High-stress levels or mental health issues may affect academic success.

Higher Education Institutions must use Machine Learning Algorithms to combine these indicators and predict student outcomes. The proposed work shall also highlight,

1. **Moving Beyond Static Data Analysis:** Traditional Predictive Analytics often rely on historical data to predict future performance. While valuable, this approach can miss crucial real-time signals. AI, on the other hand, leverages ML algorithms that can continuously learn and adapt.
2. **Learning patterns:** Analyzing clickstream data and interaction with learning materials can reveal how students approach tasks, identify areas of difficulty, and flag potential misunderstandings.
3. **Emotional state:** Advanced AI models can analyze patterns to gauge student engagement and potential emotional states like frustration or confusion.
4. **Adaptive learning platforms**: AI-powered platforms can adjust the difficulty of learning materials or suggest alternative learning pathways based on a student's real-time performance and emotional state.Traditional analytics often focus on averages and broad trends. AI, on the other hand, excels at identifying complex patterns within vast datasets.
5. **Personalized learning paths:** AI algorithms can analyze a student's background, learning style, and historical performance to recommend tailored learning materials, suggest appropriate learning methods (visual, auditory, kinesthetic), and even predict optimal class sizes or learning environments.
6. **Early intervention for at-risk students**: By identifying subtle changes in learning patterns or emotional states, AI can predict students at risk of academic difficulty before they fall behind. This allows for early intervention with targeted support, such as personalized tutoring or mental health resources.
7. **Automated grading and personalized feedback**: AI can handle routine tasks like grading multiple-choice questions, thus freeing up educators' time to provide more in-depth, personalized feedback.
8. **Data-driven instructional strategies**: AI can analyze student performance data to identify areas where the entire class might be struggling or where specific teaching methods might not be effective. This empowers educators to adjust their teaching strategies based on real-time insights.
9. **Collaboration between AI and educators**: AI can act as a valuable assistant, providing educators with data-driven recommendations to tailor their teaching approaches to individual student needs and learning styles.

This is achieved by coming forward with AI Enabled Prognostication system. This will also help to come with stakeholders Recommendation System that can automate all such processes. Although stakeholders' participation causes low variance in students' academic performance but the role of Parents, Teachers, Peers, etc. Some contemporary studied have shown that students who get more support from their Teachers, Parents, Peers, and learning environment have better academic outcomes. The findings of the proposed Research could be potentially useful for Policymakers and Stakeholders to ensure the elevation in students' engagement and their academic performance in studies.

2. Literature Review

This section reviews key studies and frameworks, providing a foundation for the underlined research work and possible innovative applications, being discussed later.Each of these areas underscores the potential of Academic Analytics to transform Educational ecosystems through data-driven insights and strategic interventions. Academic Analytics is the application of data analysis and visualization techniques to improve decision-making and strategic planning in educational institutions. By leveraging data from various sources such as student performance, institutional resources, and administrative records, Academic Analytics supports enhanced learning outcomes, institutional efficiency, and policy-making. This review delves into significant research, theoretical frameworks, methodologies, and case studies in Academic Analytics, with a focus on global practices and insights specific to India.Academic Analytics differs from learning analytics, focusing on institutional decision-making rather than individual learning processes. Important aspects include:

1. **Data sources:** Institutional Databases, Learning Management Systems (LMS), and External Benchmarks.
2. **Tools andtechnologies**: Statistical Analysis, Machine Learning, Artificial Intelligence, and Visualization Tools.
3. **Stakeholders:** Administrators, Policymakers, Faculty, Students, Alumnae, Peers and Institutional Researchers.

Our studies have found that the reviewed literature primarily considers following Theoretical frameworks for Academic Analytics,

1. **Decision Support Systems (DSS):** Early research focused on the role of DSS in higher education decision-making. Analytics evolved as a subset, emphasizing evidence-based policies.
2. **Data-Driven Decision-Making (DDDM):** Institutions adopting DDDM integrate analytics into strategic processes to enhance resource allocation and academic performance.
3. **Predictive Analytics:** A key area of Academic Analytics, predictive modeling helps forecast student success and identify at-risk students.

Our studies have found that the reviewed literature primarily considers following Methodologies for Academic Analytics,

1. **Descriptive Analytics**: Visualizes historical data trends, Common tools: dashboards and reporting systems.

2. **Predictive Analytics**: Machine Learning models like Decision Trees, Regression, and Neural Networks, Applications in student retention and enrollment management.
3. **Prescriptive Analytics**: Suggests actionable strategies based on predictive insights, Example: Optimizing course schedules based on demand predictions.

Our studies have found that the reviewed literature primarily considers following applications Academic Analytics,

1. **Student Success:** Tracking and predicting student performance to offer timely interventions, Example: Purdue University's Course Signals system.
2. **Resource Optimization:** Efficient allocation of faculty and facilities based on analytics.
3. **Policy Formulation:** Supporting policy decisions like admissions criteria adjustments or financial aid distribution.
4. **Institutional Rankings and Accreditation:** Leveraging analytics to improve metrics impacting rankings.

Our studies have carefully studied following Case Studies for setting our research objectives. These references showcase the diverse applications of AI and ML in Academic Analytics, from Predictive Modeling to Ethical Considerations, ensuring improved student success and institutional efficiency.

1. **Global Case Studies**:
    a) University of Michigan: Deployed Predictive Analytics to reduce dropout rates by 25%.
    b) Arizona State University: Used analytics to improve graduation rates by 20% over six years.
2. **Indian Context**:
    a) National Institutional Ranking Framework (NIRF): Analytical tools play a pivotal role in ranking Indian universities.
    b) Central Universities: Implementation of dashboards for real-time performance monitoring.
    c) State-Level Initiatives: Use of analytics for enhancing Gross Enrollment Ratio (GER) in states like Tamil Nadu.
    d) IIT Bombay: IIT Bombay uses Machine Learning Algorithms to predict student success and optimize resource allocation.
    e) Manipal Academy of Higher Education: The institution employs AI-driven platforms to personalize student learning experiences.
    f) CBSE (Central Board of Secondary Education): AI-enabled analytics help CBSE track and improve school performance across regions.

3. **Pioneering works by Siemens and Long (2011)**: Highlighted the potential of learning analytics in higher education. In India, research by institutions such as IITs and NITs focuses on employing AI to predict academic outcomes and optimize resource allocation.
4. **Chen, F. et al. (2023):** This study focuses on utilizing Machine Learning Algorithms like Support Vector Machines (SVM) and Random Forest (RF) for Predictive Analytics in education, achieving high accuracy in chronic disease predictions. It underscores the role of advanced AI techniques in improving decision-making in academic contexts
5. **Holmes, W. (2018)**: Examines the ethical integration of AI in education, advocating for cognitive and moral considerations when deploying AI in learning systems
6. **Gandomi A. H. et al. (2023)**: Explores Big Data Analytics in education using AI to extract insights from large datasets, highlighting its scalability and efficiency
7. **Van VlietA. (2023):** Discusses the responsible use of generative AI tools in academic research, addressing concerns about data privacy, transparency, and ethical deployment
8. **Alkhatib, A., & Valentine, M. (2023)**: Investigates the use of predictive models to improve student outcomes by analyzing data from online learning platforms.
9. **Choi, S. et al. (2022)**: Evaluates adaptive learning systems driven by AI, showing their effectiveness in customizing educational experiences.
10. **Sharma, P., & Singh, S. (2022)**:Demonstrates how Natural Language Processing (NLP) models enhance feedback systems in e-learning environments.
11. **Zhang, T., & Huang, X. (2023)**: Focuses on emotion detection through Deep Learning in educational settings, linking student engagement with academic performance.
12. **Lee, J. et al. (2022)**: Applies neural networks for plagiarism detection, improving academic integrity in digital submissions.
13. **Mitra, S., & Banerjee, A. (2022)**: Uses clustering algorithms to identify at-risk students in large academic datasets.
14. **Wang, Y., &Siau, K. (2023)**: Discusses AI's role in grading and its impact on reducing biases while maintaining fair assessment standards
15. **Ahmed, N. et al. (2023)**: Develops Hybrid ML models to predict course completion rates in MOOCs (Massive Open Online Courses).
16. **Kim, H. et al. (2022)**: Studies collaborative learning analytics systems enabled by AI to optimize group project dynamics.
17. **Patel, A., & Kumar, P. (2022)**: Explores reinforcement learning in academic game design to motivate and engage students.
18. **Rodriguez, F., & Garcia, M. (2023)**: Analyzes text mining techniques for identifying trends in research outputs and academic discourse.

19. **Nguyen, P. et al. (2023)**: Focuses on AI-based simulation tools for training educators in virtual classroom management.
20. **Johnson, R., & Smith, L. (2023)**: Evaluates Predictive Analytics to enhance library resource management and optimize student access.
21. **Chin, T. (2023)**: Discusses the use of translation AI tools to promote Multilingual Learning Environments in Universities
22. **Frey, C., & Osborne, M. (2023)**: Examines AI's broader impact on education and workforce readiness, emphasizing evolving skill requirements
23. **Dalhousie University Initiative (2023)**: Highlights the integration of AI into campus apps to improve academic services and student experience
24. **Siemens, G., & Long, P. (2011)**: Penetrating the fog Analytics in learning and education.
25. **Papamitsiou Z., & EconomidesA. A. (2014)**: Learning analytics and educational data mining in practice.

3. Research Objectives

These objectives cover a wide spectrum of areas, including institutional processes, student outcomes, technological innovations, and ethical aspects, ensuring a comprehensive research framework.

1. To analyze the Current State of Academic Analytics in higher education institutions and identify key gaps and challenges.
2. To explore the Role of Academic Analytics in improving institutional decision-making processes.
3. To identify Key Performance Indicators (KPIs) for evaluating the effectiveness of Academic Analytics in higher education.
4. To examine the Impact of Academic Analytics on student academic performance student retention and success rates.
5. To assess the Role of Academic Analytics in optimizing resource allocation and utilization.
6. To evaluate the Effectiveness of Academic Analytics in predicting student performance and learning outcomes.
7. To study the Impact of personalized learning pathways, enabled by Academic Analytics, on student engagement and satisfaction.
8. To investigate the Role of Academic Analytics in identifying at-risk students and providing timely interventions.
9. To assess the use of Academic Analytics in improving the quality of feedback provided to students.
10. To explore the Integration of Academic Analytics with student support services to enhance academic outcomes.
11. To assess the Scalability and Adaptability of Academic Analytics platforms in diverse higher education settings.
12. To investigate how Academic Analytics can assist in Curriculum Design and Improvement.
13. To evaluate the Role of Academic Analytics in aligning institutional goals with national and international accreditation standards.
14. To study the Cost-Benefit Implications of Implementing Academic Analytics in higher education institutions.
15. To examine Ethical considerations and Data Privacy Challenges in the implementation of Academic Analytics.

4. Research Methodology

A robust Research Methodology ensures that the study of implementing Academic Analytics in higher education is systematic, reliable, and actionable. Here's a step-by-step framework of our proposed research,

1. Research Design

- **Type**: Mixed-Methods approach (quantitative and qualitative) to address the technical, operational, and social aspects of Academic Analytics implementation.
- **Focus**: Exploratory for identifying challenges and requirements, and descriptive for analyzing the impact of Academic Analytics.

2. Data Collection Methods

a. Secondary Data Collection

- **Sources**:
    - Institutional Databases (enrollment, grades, attendance, results, etc.)
    - Learning Management Systems (LMS) logs
    - National Education Datasets (e.g., UGC, AICTE in India)
    - Academic Research Papers and Reports.
- **Purpose**: To establish baseline metrics and identify trends in academic performance and resource utilization.

b. Primary Data Collection

- **Surveys**:
    - For students: Understanding their perceptions of personalized learning and academic interventions.
    - For faculty: Gauging acceptance, challenges, and potential use cases.
    - For administrators: Insights into decision-making improvements.
- **Interviews and Focus Groups**:
    - Stakeholders: Administrators, Faculty, Students, and IT Professionals.
    - Purpose: To gain qualitative insights into implementation challenges and expectations.
    -

- **Observations**:
    - Monitoring Academic Analytics tool usage in pilot studies.

3. Data Sampling

- **Population**: Higher Education Institutions (diverse in size, type, and focus).
- **Sampling Techniques**:
    - Stratified sampling to ensure representation across types of institutions (public, private, rural, urban).
    - Purposive sampling for pilot institutions with prior interest in analytics implementation.

4. Data Analysis

a. Quantitative Analysis

- **Tools**: Statistical Software (e.g., SPSS, R, Python).
- **Techniques**:
    - Predictive Analytics for student outcomes (using Machine Learning Algorithms models like Regression, Decision Trees, etc.).
    - Descriptive Statistics for understanding trends in institutional data.
    - Inferential Statistics (e.g., Hypothesis Testing, ANOVA) for comparing performance pre- and post-implementation.

b. Qualitative Analysis

- **Tools**: NVivo or manual coding.
- **Techniques**:
    - Thematic analysis for interview and focus group data.
    - Sentiment analysis for survey responses.

5. Technology and Tools

- **Data Warehousing**: For collecting and storing structured and unstructured data from multiple sources.
- **Analytics Platforms**: Tableau, Power BI, or custom dashboards for data visualization.
- **Machine Learning Frameworks**: TensorFlow, Scikit-Learn for predictive modeling.
- **Database Management**: SQL and NoSQL systems for efficient data handling.

6. Implementation Strategy

- **Data Collection:** Gathering data from Learning Management Systems, Institutional records, and Student interactions.
- **Preprocessing:** Cleaning and anonymizing data to ensure ethical use.
- **Algorithmic Techniques:** Applying AI, ML, DL algorithms like SupervisedLearning, Unsupervised Learning, and Deep Learning models for insights.
- **Visualization:** Using tools like Tableau and Power BI for actionable insights.
- **Pilot Testing**: Select 2-3 institutions as case studies, Implement Academic Analytics tools in phases (e.g., Data Collection, Visualization, Intervention Strategies).
- **Feedback Mechanism**: Collect feedback post-implementation from all Stakeholders to identify challenges and success factors.
- **Integration of AI and ML**: Automated insights for proactive decision-making.
- **Personalized Learning Pathways**: Tailoring curriculum and assessments based on student analytics.
- **Focus on Sustainability**: Analytics for achieving Sustainable Development Goals (SDGs) in education

7. Validation of Findings

- **Cross-Institutional Comparison**: Compare results across institutions to test generalizability.
- **Expert Review**: Seek input from education data analysts and policymakers to validate conclusions.

5. Challenges &Ethical Considerations

1. **Data Privacy and Ethics:** Balancing Analytics with GDPR and other data protection regulations.
2. **Scalability:** Handling large datasets with limited infrastructure in developing nations.
3. **Resistance to Change:** Stakeholder apprehension toward data-driven practices.
4. **Skill Gaps:** Limited expertise in analytics among educational administrators.
5. **Informed Consent:** Obtain consent from participants involved in surveys or pilot testing.
6. **Bias Mitigation:** Ensure fairness in data collection and model development.
7. **Algorithmic Bias:** Preventing biases that could marginalize certain groups.
8. **Technical Barriers:** Limited access to infrastructure and expertise in some regions.

Addressing these challenges requires robust policy frameworks and ethical guidelines.

6. Possible Outcomes

1. Academic Analytics has emerged as a transformative tool in education. While global practices showcase advanced implementations, India's progress reflects a growing emphasis on data-driven governance.
2. The research would explore interdisciplinary approaches, integrating psychology, technology, and educational theories to expand the scope of Academic Analytics.
3. The research methodology combines data-driven analysis with Stakeholder insights, ensuring that the implementation of Academic Analytics is both effective and sustainable.
4. It will result into a framework for implementing Academic Analytics tailored to higher education institutions.
5. Predictive Modelling
6. Learning Analytics
7. Administrative Insights
8. Outcome Analysis
9. Moving beyond Statistics for actual data driven analysis

7. Conclusion& Time Schedule

Conclusion:

The integration of AI and ML into Academic Analyticshas the potential to transform Education, particularly in a diverse country like India. By addressing challenges and leveraging advanced technologies, Stakeholders and Policy Makers can foster inclusive, efficient, and impactful learning environments for betterment of students' academic performance.

Time Schedule:

Task	Year 1				Year 2				Year 3			
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
Literature Survey	----											
Planning	----	----	----									
Deciding Technique			----	----								
Preparation of Data				----	----							
Applying the Method and obtain the outcome					----	----	----	----				
Testing and Verification of Results								----	----	----	----	
Documentation, Thesis Writing etc.											----	----

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